PROGRESS REPORTS

FROM

EXPERIMENT STATIONS

SEASON 1957-58

ADEN PROTECTORATE

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PROGRESS REPORTS FROM EXPERIMENT STATIONS

The reports for the seasons up to and including 1950-51 were published in seasonal volumes; the following are still in print and available at 3/- per volume post free.

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From 1951-52 the reports from each territory were published individually each season. A few of the 1951-52 reports are out of print, but all others are available post free at 1/- per report or 7/6d. for the seasonal set.

ADEN PROTECTORATE

RESEARCH SECTION, EL KOD
PROGRESS REPORT FOR THE SEASON 1957-58

BY

K. R. M. ANTHONY, J. E. A. OGBORN and J. H. PROCTOR

Planting dates.	*Picking dates.*	*Close season.*
Mid August-mid October.	January-May.	June-mid August.

Introduction

General

Security in Abyan deteriorated towards the end of 1957. As a result, movements of officers were restricted and all survey work had to be curtailed. It was unfortunate that Mr. R. C. Maxwell-Darling, consultant entomologist to the section, was involved in the first incident, an attempt, happily unsuccessful, being made to shoot him whilst he was engaged in field work near the main canal. Field experimentation and laboratory work were not affected.

The post of entomologist, vacant since April 1957, was filled in early January with the appointment of Mr. J. H. Proctor. Before joining the Corporation Mr. Proctor was entomologist to the Department of Agriculture, British Guiana.

Two consultants worked at the station during the winter months. Mr. R. C. Maxwell-Darling was at El Kod for six months, from October to April, studying cotton pest problems and advising on the future programme of work in entomology. Mr. C. Logan, plant pathologist, Namulonge, spent ten weeks at the station and undertook a study of Abyan root rot of cotton. Both have contributed to this report.

Mr. J. C. May visited El Kod in December for discussions with staff. Other visitors to the station during the year included: H.E. The Governor of Aden, Sir William Luce, K.C.M.G., K.B.E.; Mr. G. Lacey and Mr. G. M. Roddan, Adviser on Drainage and Irrigation and Deputy Agricultural Adviser to the Secretary of State, respectively; and M. de Carbon-Ferrière, Director General, Compagnie Française pour le Développement des Fibres Textiles.

Irrigation

The 1957 summer floods were well above average in volume, no less than 144·3 million cubic metres being recorded at the headworks of the Wadi Bana in April and May alone. A high proportion of this was lost to the sea, but from Abyan Board records it is estimated that

about 10 thousand acres were watered from a volume of about 72 million cubic metres, equivalent to 18 thousand acre metres of irrigation water. By contrast, only 94·4 million cubic metres were recorded during July, August and September. Fortunately these floods were small and well distributed, and it is estimated that not more than 8·5 million cubic metres were lost down the Wadi Bana to the sea. A further volume was also lost by breakouts to the sea through the coastal irrigation works. The total utilised for irrigation was therefore about 82 million cubic metres. Abyan Board records suggest that a total of 33·4 thousand acres of various crops were sown during this period. Of this total, 31·7 thousand acres were recorded as cotton. Past experience suggests that both the total acreage and the proportion of cotton have been exaggerated and that the effective acreage picked was of the order of 25 thousand acres.

During the sowing season a permanent flow of 15 cubic metres per second was recorded in the Wadi Tiban at Lahej, in addition to which there were nine floods, each of one to three days duration. Of the 160 million cubic metres recorded between July 17 and October 15, an estimated 115 million cubic metres passed into the canalisation system. The estimated loss of water in transit to the field was of the order of 30 per cent., and thus the effective amount of water used for irrigation was calculated to be 80 million cubic metres. We are indebted to Mr. J. J. Barraud, F.A.O. Irrigation Consultant, for this information on the Wadi Tiban, and to Mr. F. H. Downing, Chief Engineer, Abyan Board, for that on the Wadi Bana.

No comparable flood data are available for any of the other wadis in the Protectorate. Rains in the coastal strip during the July-September period were light and floods in wadis, dependent on run-off in this area, were below average. In consequence there was no effective cotton crop in Ahwar nor the Fadhli bedouin areas.

The Cotton Crop

The bulk of the Abyan crop was sown by September 20. The standard of weeding was again poor and clean fields were the exception rather than the rule. Yields were low and the expected production is 15,000 bales (400 lb.) from approximately 25,000 acres. There was a further expansion of cotton growing in Lahej and 13,000 acres were sown, compared with 8,000 acres last season. The crop should total 12,000 bales.

Only 3,000 effective acres of cotton were cultivated in the small outside areas, Dathina contributing slightly over half. A crop of approximately 2,000 bales is expected and the total Protectorate crop should be of the order of 29-30,000 bales.

A satisfactory feature of the present crop is the improved grade compared with the last three seasons. The Abyan crop will bulk in

grade 3 and it is expected that 85-90 per cent. will be grade 4 and over, with not more than 500 bales below grade 5. Picking standards showed considerable improvement and, prompted by political uncertainty, farmers picked and brought their cotton to buying stations with the minimum of delay. As a result, pickings were not mixed to the same extent as last year. Picking was virtually completed by the end of March. Lahej cotton is expected to grade similarly to Abyan, but the small outstations crop will bulk in grades 4 and 5.

Production trends in the Protectorate are illustrated in Table 1, which covers the last five years. Cotton growing commenced in Abyan, and the organisation built up by the Abyan Board has made possible the extension of cotton cultivation to the other areas. Since 1954 there has been a pronounced drop in the production per acre in Abyan, but the emergence of Lahej as a cotton producer has increased the total Protectorate production. The smaller producers have largely contributed to the lower grades.

TABLE 1.

COTTON ACREAGE AND PRODUCTION

Season	ABYAN			LAHEJ			PROTECTORATE		
	Acreage	Bales	Mean grade	Acreage	Bales	Mean grade	Acreage	Bales	Mean grade
1953-4	20,000	19,299	2·5	—	—	—	22,000	21,736	2·6
1954-5	21,000	11,528	3·9	5,000	4,512	4·1	32,000	22,140	4·2
1955-6	18,000	15,776	3·9	7,000	10,368	3·5	30,000	30,700	3·9
1956-7	24,000	13,628	3·7	8,000	9,148	3·9	38,000	28,310	4·0
1957-8 (estimate)	25,000	15,000	3·4	13,500	12,000	3·5	41,000	29,000	3·5

PLANT BREEDING

Cotton Selection and Propagation

Twenty-five progenies were tested in a 5 × 5 lattice square design, with three replications and a plot size of 20 sq.m., at El Kod. The coefficient of variation was 10·6 per cent. Progenies selected on the basis of yield and length will form a new bulk. It is of interest to note that the relative efficiency of this design compared with randomised blocks was 162 per cent., and compared with a triple lattice 119 per cent. Further single plant selections from BAR XL1 were made for sowing and testing next season. Whilst an effort is being made to handle a larger number of progenies, the resources and staff available are limiting factors.

A seven acres bulking plot of the first bulked progenies from BAR XL1 (K1) was grown at El Kod and will supply seed for commercial bulking areas in Abyan and Lahej in the coming season. These areas will be changed next season. Security conditions have affected the

accessibility of Um Gibla and Yeramis, and poor July-October floods in the Wadi Hassan this season have demonstrated that Yeramis cannot be relied upon to produce an adequate amount of cotton every season. Two bulking areas, one of 100 acres, the other of 1,500 acres, will be established near Giar, under the direct supervision of Abyan Board agricultural staff. Because of the increased demand for cotton seed for Lahej a separate bulking scheme has been devised for that State. Classifier's first comments on the 200 acres of BAR XL1 at Um Gibla and the 250 acres at Lahej are encouraging. The whole of the Protectorate crop should be BAR XL1 in 1960.

Cotton Variety Trial

The cotton variety trial was again a 10 × 10 Latin square, plot size 42 sq.m. harvested, and was sown on September 2. Varieties comprised six Lambert types and selections, Karnak, Domains Sakel and two American Uplands. Abyan root rot of cotton caused appreciable plant mortality at the lower end of the field and an analysis of covariance was carried out. The regression coefficient of lint yield on total final plant population was very highly significant and yields were accordingly corrected for population. In Table 2 a significant difference in lint yield between any variety and AB control is indicated by the appropriate number of stars. As in other experiments in which it was included this season, a high yield was recorded for Wilds Early. Picking of the American varieties commenced on December 18, five weeks before the L cottons and 107 days after sowing. Both had a heavy second crop of bolls, which in the case of Wilds Early contributed 30 per cent of the total crop.

Table 2.

Abyan Cotton Variety Trial, 1957-58

	% GOT	Corrected lint yields	% of control
Wilds Early	34·2	1,149***	153
BAR 12/3	31·1	879	117
AB3	34·9	829	111
AB1	34·5	772	103
K1	35·1	752	100
AB Control	34·3	750	100
BAR XL1	35·1	699	93
BAR XL3	34·5	674	90
Karnak	34·2	601*	80
Domains Sakel	31·5	531**	71

Coefficient of Variation = 21·5 per cent.

Abyan Root Rot of Cotton

Work continued on the lines described in last season's report. The field chosen for planting was known to be badly infected with the disease, the previous lubia crop having completely succumbed. Fourth backcross hybrids, third backcross hybrids selfed in 1956-57 and the

first backcross to BAR XL1 of X1730A × Wilds Early were planted on three sites with BAR XL1 and Wilds Early controls. Results indicated that a fairly high measure of resistance was present in the hybrids and further selection and backcrossing were carried out.

Natural Crossing

In 1956-57 a strip, 65 metres long and 25 metres wide, running across the centre of a field of BAR XL1, was sown with BAR 5/6, an L type carrying a gene for red colour. Samples of approximately 2,000 seeds were taken from BAR XL1 rows at 1, 5, 10, 15, 20 and 25 metres distance from the BAR 5/6 on both sides of the plot. These were sown in 1957 and the percentage of red seedlings recorded. Results showed a normal degree of cross pollination. The percentage of natural outcrossing between adjacent rows was 4·2 per cent., falling to 0·04 per cent. at 25 metres, with intervening cotton.

Other Crops

Variety trials were carried out on a number of sesame and sorghum varieties introduced from the Sudan. As can be expected in the case of long established food crops, none of the importations could be regarded as superior to the local varieties. Improvement is best effected by selection within local varieties.

Agronomy

Soil Fertility

The rotation experiment completed its second year. A description of the layout is contained in the 1956-57 Progress Report. In the cotton and sorghum phases nitrogen is applied as sulphate of ammonia by placement, at the rate of 10 grm. nitrogen per planting point for cotton and 5 grm. nitrogen per planting point for sorghum. The standard practice adopted on the station is to place fertiliser 25 cm. from the planting point and at 15 cm. depth. Nitrogen responses are tabulated. The level of cotton yields was higher than last season, as was also yield increase with application of nitrogen (73 per cent.). Attack by weaver birds again invalidated the sorghum grain yield data, but the response to nitrogen is reflected in the straw yields.

Table 3.

Rotation Experiment, Giar

(*yields as lb. per acre*)

	Seed cotton	Sorghum straw
Mean yield	1324	8170
Nitrogen effect	+ 710***	+1971*
Standard Error	± 174	± 720

A forms of nitrogen experiment was again laid down at Giar comparing sulphate of ammonia with urea, application at 5 or 10 grm. nitrogen per sq.m., and two times of application, in a 2^3 design. There were four replications with two non-nitrogen plots per block. Cotton was sown on August 29 and fertiliser was applied at this date or a month later.

The standard of precision of the experiment was not high, the coefficient of variation being 24·7 per cent. The mean response to nitrogen (46 per cent.) was large and highly significant. The difference between sulphate of ammonia and urea failed to reach the level of significance, but is in conformity with last season's results. Differences between the single and double rates and times of application were small.

TABLE 4.

TYPES OF NITROGEN EXPERIMENT, GIAR

(*lb. seed cotton per acre*)

Average effect of nitrogen	+ 660**
Standard Error	± 191
Mean of nitrogen treatments	2086
N_2–N_1	+ 53
Early–late application	+ 85
Sulphate of ammonia–urea	+ 302
Rates × times	− 176
Rates × types	− 116
Times × types	− 49
Standard Error	± 184

At Kod an NPK experiment was carried out on land which was sown with cotton for the second year in succession. A 3^3 layout, with single replicate, was used, the second order interaction being confounded. Cotton was sown on September 9 and ammonium sulphate, granular superphosphate and sulphate of potash were applied by placement, at sowing, at rates equivalent to 0, 5 and 10 grm. of the main element per sq.m. Results were of particular interest as, due to the system of irrigation, the Kod farm was under flood water for ten days and the fertility of the silt might in consequence have been adversely affected.

The standard of precision of the experiment was satisfactory, with a coefficient of variation of 8·6 per cent. Main effects are given in Table 5. Significant linear responses were obtained with the application of both sulphate of ammonia and sulphate of potash. The latter was unexpected and further evidence is necessary to throw more light on its implications, if any.

TABLE 5.

NPK EXPERIMENT, EL KOD

(*Mean yield 1637 lb. seed cotton per acre*)

Factor	L	C
N	+356**	− 28
P	+ 21	+ 98
K	+168*	+ 97
S.E.	± 66	±115

A trial with similar design and treatments was carried out at Lahej by the Agricultural Officer, on the State's nucleus bulking area of BAR XL1. The land had not previously been cropped with cotton. The comparatively high mean yield of 2390 lb. seed cotton per acre was recorded from the experiment and no responses were obtained to any of the fertilisers. The coefficient of variation of the experiment was 8·0 per cent. The results were in conformity with the general appearance of the Lahej crop this season, strong vigorous growth with a high level of productivity per acre. Lahej yields have so far been maintained by a rapid expansion into new areas for cotton, a high intrinsic soil fertility and a good standard of crop husbandry. However, influenced by high prices in the first few years, cotton production has expanded out of proportion to other crops and the state is in danger of falling into the pitfalls of monocrop agriculture.

A field experiment comparing cotton irrigated from silt laden and silt free water, respectively, was carried out at Giar last season to examine the nutrient value of flood borne silt deposits. No significant differences in cotton yield were obtained. The experiment was cropped with sesame in 1957 to follow any residual effects of the silt, but again there were no significant responses. A second experiment was laid down this season comparing silt with no silt in the presence and absence of nitrogen, phosphate and potash. The water borne deposit of silt and sandy loam averaged the equivalent rate of 300 tons per acre for the experiment. Regrettably this trial was completely destroyed by root rot and no data were obtained.

Water Requirement in Abyan

At Giar farm a field experiment with two varieties, four rates of watering and presence or absence of nitrogen in 32 plots contributed further information on the water requirements of cotton in Abyan. A 4 × 2 × 2 design with two replications and four blocks was used. The treatments were: water at 10, 20, 30, 40 cm. applied before sowing; nitrogen applied by placement in the form of calcium nitrate

at a rate of 5 grm. nitrogen per sq.m.; and varieties, Wilds Early and BAR XL1. Plots were 2 × 5 m. with 2 m. buffers, sown on September 4.

Table 6.

Water Duty Experiment

Water applied (cm.)	lb. seed cotton per acre		BAR XL1 Ratio water/yield
	Wilds Early	BAR XL1	
10	1126	415	0·42
20	2118	1144	0·57
30	2495	1688	0·56
40	3805	1637	0·41
S.E. Mean	± 393		
S.D. P=0·05	1191		
C.V.	32·6 per cent		

The nitrogen effect was small, only 108 lb. per acre. The yields for Wilds Early demonstrated the general high level of yield for this variety at Giar in the season under review. The very high yield obtained with 40 cm. was due to the ability of this variety to produce a second crop of bolls late in the season in the presence of sufficient moisture.

Yields for BAR XL1 are taken as confirming that 30 cm. of water are sufficient to mature a crop more than double the average commercial yield, in spite of the marked visible salinity of the site. The large coefficient of variation makes any more detailed treatment of the results inadvisable. It should be noted in passing, however, that the ratio of water applied to yield of cotton was almost the same at 20 cm. as at 30 cm.

The most efficient use of the irrigation water was therefore made by applications of between 20 and 30 cm. Giar farm was deliberately given an even lighter watering than this in order to dry out the profile by using up the moisture reserves. The remarkably high yields achieved should be considered in relation to their associated water duties.

Table 7.

Use of Irrigation Water

Field	Watering time (hours)	Median water duty (cm.)	Yield of seed cotton (lb. per acre)	Remarks
3	5·1	16	Crop destroyed by root rot.	Control plots of root rot experiment.
6	—	About 25	1320	Rotation experiment. Special watering.
8	Not drained	About 30	Crop destroyed by root rot.	
12	7·6	24	1990	
13	—	20	1140	
15	5·8	16	2230	
16	7·0	18	2420	
20	26·6	80	2690	Field used to irrigate others.

The only low-yielding fields are those from the lower half of the farm where a complex of root rot, rising water-table and salinity presents a classical case of vicarious suffering for the agronomic sins of neighbours 'up the slope'.

It now seems well established that only 30 cm. of water are required to mature a crop of cotton in Abyan, but it seems necessary to investigate the factors which allow of such low water requirement, which is well below the few other published figures for similar areas. The irrigation experiment of 1958-59 will therefore be examined by the methods and apparatus developed by our colleagues at Namulonge Research Station.

Pre-irrigation Sowing of Cotton

A preliminary experiment on the possible practice of sowing the cotton crop before irrigation included this treatment contrasted with the normal post-irrigation sowing, in the presence or absence of sulphate of ammonia. Treatments were combined in a 2^2 design with four-fold replication in four blocks. Sulphate of ammonia was applied by placement at 5 grm. nitrogen per sq.m. at sowing. Pre-irrigation sowing took place one week before watering, with no subsequent cultivation until thinning.

The results are summarised below, yield responses being uncorrected for plant number.

Table 8.

Pre-Irrigation Sowing Trial

Treatment	Response (lb. seed cotton per acre)	Plant no. per acre
Pre-irrigation sowing vs. control	+ 618**	− 3860**
Sulphate of ammonia	+ 798**	+ 1480
Interaction sowing × fertiliser	+ 92	+ 1770
Mean yield	2422	18,280
S.E.	± 167	± 947
C.V.	13·8	10·3

This interesting development will be investigated further in 1958-59.

Cotton Spacing

In the 1957-58 experiment at Giar farm, six spacings were compared in a randomised block design with five replications. The experiment was sown on August 30 and thinned to three plants per planting point. Spacing within and between rows was every combination of 100, 75 and 50 cm. With a high coefficient of variation (27·8 per cent.) there were no significant treatment differences, but there was some indication of the superiority of the closer spacings. The mean yield for the experiment was 2,140 lb. seed cotton per acre and vegetative growth was not excessive.

Abyan Root Rot of Cotton

To obtain information on the effect of formalin and nitrogen on Abyan root rot of cotton, a 2^3 factorial experiment, with three replications, was carried out with all combinations of Wilds Early and BAR XL1 in the presence or absence of formalin and sulphate of ammonia. Formalin was applied immediately before irrigation on August 22, at the rate of 250 ml. per sq.m. and sulphate of ammonia placed at the rate of 5 grm. nitrogen per sq.m. at sowing on September 5. Plots consisted of three rows of plants with one metre buffers and counts were made of the number of wilted plants on the centre row of each plot at approximately 10 day intervals from October 17 onward.

The plant mortalities for Wilds Early and BAR XL1 were 28% and 89% respectively. The incidence of wilt on the site was very variable. The results of this rather imprecise experiment appeared to indicate that plant deaths were significantly reduced by formalin in the earlier counts and by nitrogen in the later counts. The resistance displayed by Wilds Early also appeared to be inversely related linearly to the moisture status of the soil at sowing time. Mr. M. Westmacott of Rothamsted, however, advised that the experiment should be analysed as though it were two separate 12 plot experiments, each containing only one of the varieties. He also pointed out that in 10 plots the Wilds Early was very resistant to attack, an average of only 10 per cent of the plants dying. The results from the remaining two plots in which for some reason the resistance had broken down were therefore rejected and values derived by the 'missing plot technique' were substituted. These two plots had much higher moisture content than the remainder.

The adjusted results indicated that all factors had negligible effects with 'resistant' Wilds Early. By contrast, formalin significantly controlled plant death in BAR XL1 until the beginning of November. In later counts, however, the effect became smaller than the small, non-significant control obtained by the application of sulphate of ammonia in the seed-bed.

Out-stations Experiments

The section co-operated with Agricultural Officers in a series of fertiliser trials on wheat and lucerne in the Wadi Hadhramaut and Beihan. These experiments have contributed useful preliminary information and, with further experimentation, will form the basis of future advisory work.

Soil Science

Soil Survey

Detailed surveys of individual saline areas were not possible in the past season owing to the deterioration in public security in the

Abyan area. Attention had therefore to be directed at the analysis of soil samples collected in previous years. The full results of the analysis are too voluminous to be presented here but the following generalisations can now be made.

The typical alluvial soils of the Abyan area consist of nearly equal proportions of fine sand and silt with no coarse sand fraction and less than ten per cent clay fraction. The 'feel' of this soil varies very markedly with the degree of sodium saturation and the amount of salinity. Nevertheless in the field this type of soil seems to show satisfactory physical characteristics for irrigation, so long as the water-table is kept low enough. High salinity is almost invariably confined to the top 60 cm. of the profile. The saturation extract may rise as high as 2000 m.eq./l. at the surface, but rarely exceeds 30 m.eq./l. below 60 cm. High salinity in the surface is associated with the development of a high exchangeable sodium percentage in the deeper parts of the profile. Non-saline soils have sodium saturation contents of the order of 4 per cent, while those of the saline profiles may rise to as much as 40 per cent. The correlation coefficient for salinity of the saturation extract in the upper 30 cm. and the mean exchangeable sodium percentage for all typical soil profiles analysed so far is 0·90.

In any field, the higher parts of the field surface are more saline than the lower parts. Where the water is allowed to 'die' in the field after irrigation there is also usually a small intensely saline patch where the last puddle evaporates. This is less important however than the increased salinity which occurs in the upper portions of the field as a result of evaporation. It has been noted that when the height of the water-table is critical the first signs of visible salinity occur on the sides of the field banks and the high spots in the field. In the fields which have been kept under observation by the soil chemist, those which are normally emptied into another field after irrigation have been noted as being slower to deteriorate than those in which all the water in the field soaks in. It is tempting to associate this with the increased salinity measured in these fields before visibly saline deterioration commences, but unfortunately most of these fields occur as depressions in the general surface relief and are therefore nearer the general level of the water-table than their neighbours which are emptied into them. It must also be remembered that given a dynamic water-table following the general slope of the land, the upper side of a field will normally be nearer the water-table than the lower if any degree of terracing has developed. All the older areas have developed a terraced pattern. Undoubtedly the general level of the water-table is the major factor controlling the development of salinity.

The typical features of an Abyan salt marsh may be summarised as follows. A shallow depression below the general level of the

surrounding slope underlain by deep coarse sand. There is also a layer of coarse sand conducting shallow seepage into the marsh from the watered slopes above it. The side of the marsh on the downward slope is ill defined and merges gradually into the typical silt loam of Abyan. The causes of the approach of the water-table to the surface seem to be the depression of the soil surface combined with the greater horizontal permeability of the coarse sand layer above the marsh relative to that of the silt loams below the marsh.

It is not known whether there exist deep impermeable layers underneath the coarse sand, nor is it known whether considerable artesian pressure occurs. The few piezometer tubes which it has been found possible to install into the deeper coarse sand gave inconclusive results, but it would appear that if pressure exists it is of the order of only a few cm. for most of the year. In the slopes above the salt marsh area the coarse sand may only be 5 cm. thick, but it is very permeable and is considered to carry most of the lateral flow of drainage water. The impermeable 'Hodge' layer has not been found outside the quite important area described in the 1955-56 annual report.

No differences in pressure above and below the layers have been found in the few places where tubes have been installed.

From the evidence given above it cannot yet be settled whether or not the salt marsh areas are fed by deep subterranean springs, but the balance of evidence indicates that this is unlikely and that any effects are small and unimportant compared with the effects of local seepage through the shallow coarse sand lenses.

Movement of Water-table

The records kept of the water-table in wells go back to 1950, but unfortunately they are difficult to interpret owing to the uncertainty whether the levels measured were the true static levels or the 'draw-down' levels caused by withdrawing water from the wells. It can be said however that they show a clear upward trend during the period in the area north of Giar.

The records of water-table movements derived from perforated observation tubes are much more easily interpreted. An analysis of the generalised movement of the water-table in the area bounded Giar-El Husn-Dirgag and Ober Othman shows an upward movement of 61 cm. from January 1956 to January 1958. This rise of almost exactly one foot per year just misses statistical significance. On the small area of Giar Farm the rise was 68 cm. in two years and was statistically significant. The lower fields at Giar are now becoming visibly saline in patches and crop yields are already suffering. Unexpected confirmation of the existence of seepage was obtained in

the current season from soil samples taken in the rotation experiment to determine the amount of water used by the rotation crops of sorghum and lubia. Table 9 is self explanatory.

TABLE 9.

MEAN MOISTURE CONTENT AND DEPTH OF WATER-TABLE.

Date	September 1957	January 1958
Mean % moisture of 15 plots sampled to 230 cm.	14·3	19·3
Depth of water-table in cm.	320	290

It is of interest to consider the movement of the water-table in the Ba Tais canal in 1956-57. The amount of water entering the Ba Tais canal area in July, August and September of 1956 was the unusually low volume of 26·4 million cubic metres, as opposed to 35·1 and 31·9 in 1955 and 1957 respectively. As recorded in the annual report of 1956-57, there was a general decline in the level of the water-table of as much as a metre in some places by January 1957. In 1956 and 1958 the beginning of January was a time of maximum water levels. During the Gheil and Seif periods of 1957, however, 13·3 million cubic metres entered the canal as opposed to 8·7 in 1956. A very rapid rise in water-table then took place so that the previous levels were regained and surpassed by June 1957. It is concluded therefore that the movement of the water-table in the area is primarily influenced by the amount of water currently being applied in excess of the irrigation requirement.

Total Watering Efficiency

In this section, the term 'total nominal efficiency' refers to the fraction of the water passing the Ba Tais headworks which is used in evapo-transpiration. Similarly, 'nominal field efficiency' refers to the fraction of the water actually absorbed by the soil surface of the field which is used in evapo-transpiration. The best estimate of evapo-transpiration is not more than 30 cm.

A pattern of distribution of irrigation water has now emerged which is evidently not based on technical considerations. The Kharif flood of 1957 gives a fair example of what is happening.

TABLE 10.

DISTRIBUTION OF IRRIGATION WATER

Irrigation system	Estimated volume in thousands of acre m., and days of flow	Reported acreage of crops in thousands	Apparent mean duty cm.	Nominal total efficiency 1957	Nominal total efficiency 1956
Ba Tais Main and	7·8(73)	8·5	92	0·32	0·41
Ba Oma	2·7(41)	4·7	57	0·53	0·69
Wadi Bana	10·0(59)	19·0	53	0·57	?

Allowing for the acknowledged inaccuracy of the acreage figures, and the possibility that some water may have been received direct from the unrecorded Wadi Hassan, it is still evident that Ba Tais canal area uses water most inefficiently in spite of being run at a much higher proportion of its designed capacity. It is therefore not surprising that this is also the area where the most extensive and best developed salinity is to be found.

The increased efficiency observed in 1956 occurred under the spur of a vigorous 'light-watering' campaign conducted by the Research Station and the Agricultural Inspectorate of the Abyan Board. The pattern of watering priorities remaining unchanged, the difference must therefore be attributed almost entirely to the increased 'field efficiency' of the co-operating farmers. There still remained many examples of deliberate gross over-watering.

If the mean annual figures for 1951-57 are considered, Table 11 shows that the distortion of the watering system under political pressure has been a constant feature throughout the period.

Table 11.

Efficiency of Watering, 1951-57

Irrigation system	Designed capacity cu. m. secs.	Mean annual volume in million cu. metres	Equivalent volume in thousand acre metres	Nominal mean annual efficiency
Ba Tais	5	48·4	12·3	0·35
Main and Ba Oma	40	39·7	9·8	0·47

The main canal area therefore has been consistently more efficient in spite of the reputation for intransigence of the inhabitants. It is however probable that the efficiency is due mainly to low supply and high demand rather than a high standard of watering discipline.

It is probable that the latest improvements in the Ba Tais headworks will ensure that a considerably higher proportion of the water will be directed into the headworks canal system in the summer of 1958. Most of this water will perforce go into the main canal. Unless regulations are enforced to ensure its economical usage and widespread distribution into infrequently watered areas it can be confidently predicted that this extra water will go to swell the drainage burden of the Ober Othman-Dirgag salt marsh area.

Entomology

by

R. C. Maxwell-Darling and J. H. Proctor

The lack of precise information on the importance of the different species on Abyan cotton made necessary a general survey of the delta. To the limitations imposed on this survey by staff and facilities

were added the deterioration of security. Important cotton growing areas in the north of Abyan could not therefore be included in the survey, which in the main was confined to the south of a line from Giar to Husn. The survey involved the inspection of the cotton and the collection of green bolls in selected sampling areas. The bolls thus collected were opened and examined in the laboratory.

Four species of bollworms have been found in Abyan cotton—*Diparopsis watersi* Roths., *Earias insulana* Boisd., *Heliothis armigera* Hbn. and *Platyedra gossypiella* Saund. *Diparopsis* was this year the only one of any general importance, *Earias* being rarely found and *Heliothis* limited to local attacks in small areas. *Platyedra* was found only in the last stages of the crop, and only in one locality in Abyan.

Diparopsis occurred wherever boll collections were made, but from the indications gained in the survey and in more detailed studies at El Kod it appears not to have been a serious pest in 1957-58. It was found on cotton as soon as buds were formed, but the infestation remained light until February, by which time probably half the crop had been picked.

Aphis gossypii Glover occurred during the season in infestations of varying intensity throughout Abyan, and may well have caused as much loss of crop as *Diparopsis,* although it was more localised in its incidence.

Diparopsis watersi

Survey.—Seven sampling areas were selected for the inspection of the cotton and the collection of bolls. Each area was visited at convenient intervals and the fruiting points collected from twenty plants selected at random. From January onwards the twenty plants were taken from four different fields scattered over the area rather than from one field, as previously. Also, from January, it was impossible to examine all fruiting points on the plants and only the green bolls were collected.

Diparopsis, which was not a serious pest in 1957-58, was found as soon as buds were formed, being first noticed in mid October on the early budding Wilds variety. When budding became general in early November the bollworm was found in small numbers on all cotton examined. The number of damaged buds was usually less than 5 per cent, in one instance however reaching 23 per cent, but many of the damaged buds were undoubtedly shed and therefore not counted. The numbers of other bollworms found, except at the very end of the crop when *Platyedra* was found, were so small that the numbers of damaged bolls could be regarded as the numbers damaged by *Diparopsis.*

Study of crop loss due to Diparopsis.—An observation plot of 1,000 sq.m. on the El Kod Research Station was sprayed weekly with

endrin emulsion at the rate of 200 grm. endrin in 200 gallons water per acre. A similar plot was marked out for comparison, and weekly plant diagrams were made of 20 plants from each plot. In the event, growth was much better on the unsprayed plot than on the sprayed, and the endrin did not by any means completely protect the cotton against *Diparopsis*. Nevertheless, useful information was gained on the pattern of shedding at various stages of growth and the importance of *Diparopsis* as a cause of shedding.

Endrin may have protected the buds of the sprayed cotton from *Diparopsis* in the earlier stages, but the poor growth of this cotton may have made it less attractive to gravid moths than the taller cotton surrounding it, and no firm conclusion can be drawn. It certainly failed to protect buds and bolls when *Diparopsis* became more common in February.

The proportion of damaged buds and bolls found in shed collections remained low until the end of January. This confirms the indications of the field survey results that *Diparopsis* did not become numerous until the latter stages of the crop.

There was a high rate of bud-shedding during the period in December and January when the first crop of bolls were maturing. The larger part of this shedding was not due to *Diparopsis,* and many of the buds which were attacked and shed would in all probability have been shed in any event. Later the amount of natural shedding was reduced, and as *Diparopsis* became more common it became the principal cause of shedding. The total shedding, however, was less, and the shedding of buds after the latter part of February is unimportant, as buds formed after this time would not mature into ripe bolls before the end of the crop. Similarly the heavy boll-shedding which occurred in January was principally natural shedding, and *Diparopsis* became the principal cause of boll-shedding only in February, when total shedding was in any event very much less. The shedding of young bolls after the latter part of March is not important, as they would not open before the end of the crop.

The crop loss due to *Diparopsis* appears therefore to have been mainly that due to attack on the maturing green bolls, losses through shedding appearing to have been relatively trivial. While the percentage of green bolls damaged by *Diparopsis* found in boll collections during the survey needs adjustment to allow for bolls shed, it nevertheless appears to indicate the extent of crop loss due to *Diparopsis,* which appears to have built up its numbers too slowly to have caused any drastic loss of crop.

In two instances *Diparopsis* was found attacking the growing point.

Diapause investigations.—Diparopsis larvae in the last instar collected from green bolls at different times from January onwards were made to pupate in 4 inch diameter steel mesh cylinders sunk

in the soil and surrounded by a kerosene-water channel to exclude predatory ants. No conclusions can yet be drawn from emergence records, but it appears that emergences ceased with the onset of higher temperatures in late April-May.

Aphis gossypii

On the sprayed and unsprayed plots at Kod counts of leaf insects were made on 100 upper, 100 middle and 100 lower leaves at weekly intervals. Both plots showed two peak infestations of *Aphis,* the first in early January and the second in late February and March. Although the first infestation was lighter on the sprayed cotton than on the unsprayed, the March infestation was equally severe in both.

Infestations of varying severity were found in places all over Abyan. The most severe infestations were in tall, lush cotton and poorly grown plants were not heavily infested. Much honeydew was produced on the leaves, which were then covered with sooty mould. Heavy shedding of leaves and fruiting points occurred on infested sympodia, and remains of sooty mould were generally to be found on plants with bare lower sympodia.

While it was more localised in its incidence, *Aphis* may well have caused as much loss of crop as *Diparopsis.* Its incidence may be connected with that of wild cucurbitaceous weeds in the cotton fields.

Other Species

Platyedra gossypiella.—This was not found in Abyan until mid March, and it was then found in increasing numbers in cotton on and around the El Kod Research Station. It therefore was found only at the end of the crop, and surveys to determine the area infested were limited by the ending of the crop and the release of grazing animals into the cotton fields. Many farmers, however, left the cotton unpulled, and following regrowth *Platyedra* was found in small boll collections made in May.

Larvae could easily be found in open bolls in the first half of April, but samples of seed cotton taken during the later half of the month contained no active or resting larvae. Larvae collected from green bolls in early April were kept singly in tubes under laboratory conditions and a record kept of their pupation. Results are given in Table 12.

Table 12.

Platyedra Larval Counts

No. of larvae	No. died	No. pupated	No. in diapause
312	89	222	1

Platyedra was also found at Meifa Hajar, in the East Aden Protectorate, and the bringing of seed cotton from this and other

out-stations where *Platyedra* may occur to the El Kod ginnery, around which the infestation appeared to be centred, suggests that *Platyedra* might have been introduced in such consignments of seed cotton. Late instar larvae were first found, however, only five days after the first of these consignments was received at the ginnery, and it is therefore believed that *Platyedra* was previously established in Abyan.

Heliothis armigera.—This bollworm appeared on early-budding American cotton in October and was then found in small numbers until the end of January, when it disappeared. Two local outbreaks were seen in December, the plants recovering from the loss of buds. *Heliothis* was also common on *Dolichos lablab,* but larvae were scarce on tomatoes and maize.

Earias insulana.—Spiny bollworm was very rarely found in cotton, less than twenty larvae being found in all boll samples collected. It could always be found in *Sida mutica,* a very common weed in Abyan, 1-3 per cent of the fruits being attacked. It occurred also in *Hibiscus esculentus.* At Meifa Hajar, however, in East Aden Protectorate, it was common in the cotton, and it was common also in cotton at Bir Ahmed near Aden.

Empoasca sp.—Jassids were found only on *Solanum melongena* in October, the species concerned being *Empoasca benedettoi* Paoli, and cotton was not colonised until November. The leaf counts made at El Kod showed the sprayed cotton to be colonised later than the unsprayed, and to be less heavily infested until near the end of the crop. There was no rapid build up of jassids, populations remained low until January, and although some leaf damage was seen towards the end of the crop it was probably too late to cause any significant loss.

Jassids also occurred on *Hibiscus esculentus* and *Solanum dubium* but numbers were small on the latter.

Podagrica sp.—Fleabeetles did not appear on cotton until December, and although they increased in January and February and caused some leaf-holing and scarring of the bolls, they never became numerous enough to be serious. The beetles were abundant throughout the season on *Sida mutica,* and *Podagrica puncticollis* Wse. occurred on *Hibiscus esculentus.*

Sphenoptera gossypii.—This stem borer caused a considerable loss of young plants in October and November, but loss became slight as the season advanced.

Minor pests.—Some instances were found of primary attack on young plants by *Microcerotermes diversus* Silvestri.

The larvae of *Acontia* sp. were common on the lusher cotton during the first half of the season, but caused no severe defoliation.

Scirtothrips africanus and *Sericothrips* sp. were common on the green bolls, but caused no visible damage, while other thrips occurred on the flowers, but only in very small numbers on the leaves.

Oxycarenus sp. was present in small numbers on open bolls, and *Ferrisiana virgata* (Ckll.) occurred sporadically except on the sprayed cotton, where it increased throughout the season until March, when this cotton was heavily infested. *Bemisia* sp. was seen only rarely.

ABYAN ROOT ROT OF COTTON

BY

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An intensive study of Abyan root rot of cotton was undertaken at El Kod Research Station during the months of October and November 1957, to establish the identity of the causal organism and the factors predisposing to the disease. A full account of this investigation has been reported elsewhere. (E.C.G. Review, Vol. 35, No. 3, 1958.)

A number of fungi and bacteria, isolated on various agar media, were separately inoculated into healthy plants. None of these produced wilt symptoms, suggesting that if the real parasite was included in these isolates, some special conditions regulate the parasitism of the organism and were absent in these infection experiments. Because of its catholic host range and the disease symptoms, perhaps the most likely pathogen amongst the isolates is *Pseudomonas solanacearum*. The results of infection experiments with this bacterium, being carried out by Dr. W. J. Dowson of the Botany School, Cambridge, are awaited with interest.

The factors predisposing the plants to the disease are not yet perfectly understood, but it is thought that the source of the trouble has been the build-up of the inoculum potential of the pathogen by continuous cotton growing on the same land and leaving infected root debris in the soil. Furthermore, soil conditions produced by the rising water-table appear to favour root-rooting organisms. These conditions are the high alkalinity of the soil (pH – 9·0 approximately, strongly buffered by calcium carbonate) and the extremely high water holding capacity of the light, silty, sand loam.

The breeding of resistant varieties, soil sterilization, added fertilizer, intercropping and improvement on the present agricultural practices have been suggested as measures to control the disease.

Publications

Ogborn, J. E. A.—"A Field Method of Measuring Infiltration Rates under Basin Irrigation". Empire Cotton Growing Review, 1957. Vol. 34, pp. 263-268.

Proctor, J. H.—"A Note on Cotton Insects in British Guiana". Empire Cotton Growing Review, 1958. Vol. 35, pp. 107-110.

Willimott, S. G. and Anthony, K. R. M.—"Agricultural Research and Development in the Southwest Sudan". Parts I and II. Tropical Agriculture, 1957, Vol. 34, pp. 239-248 and 1958, Vol. 35, pp. 16-33.

Appendix

Key to Symbols used in the Report

AB Control	Rogued material from X1730A. Imported from Sudan.
AB1	Bulked selections from Sudan-Egyptian X1730A.
AB3	Second bulk filter of AB1.
BAR XL1	An importation from Sudan. First filter of BAR 1730L.
K1	First bulk filter of BAR XL1.
BAR XL3	An importation from Sudan. Third filter of BAR 1730L.
BAR 5/6	An importation from Sudan. X1730A carrying B_2 B_3 and red *arboreum* pigment gene R_2RS.
Domains Sakel	Domains Sakel, imported from Sudan.
Karnak	An importation from Egypt.
Wilds Early	American long staple type imported from Sudan.
BAR 12/3	An importation from Sudan. Fifth backcross BP52 carrying B_2.
BAR 14/25	A Sakel type from Sudan carrying B_2 and B_3, formerly known as BLR 14/25.

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